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After the initial introduction of penicillin some physicians thought that the problem of empyema had been eliminated. Of course the development of resistant organisms as well as means for the care of more elderly and debilitated patients has resulted in a resurgence of empyema. The principles of treating empyema remain the institution of appropriate antibiotics with aggressive surgical drainage. The primary care physician, by diagnosing and treating empyema early, has the best chance of preventing its serious late sequelae.

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Postgraduate Medicine

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Timely therapy for empyema

What it constitutes and why

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The development of resistant organisms and the increasing number of debilitated and elderly patients who are surviving because of modern therapy for chronic disease have resulted in a resurgence of empyema. The standard for treatment of this suppurative pulmonary disease remains appropriate antibiotics plus aggressive surgical drainage.

Empyema is a collection of pus in the pleural space. A statement by Dr Evarts A. Graham, one of the founders of modern thoracic surgery, sums up the history of therapy for this and other suppurative diseases of the lungs and chest¹:

The method gains favor for a while, sinks into oblivion and a few years later is rediscovered by some enthusiast who is ignorant of the fact that his method has already had one and perhaps two or three periods of approval followed by disuse.

At various times as new antibiotics have been introduced, the surgical treatment of empyema has been underrated or ignored. Resistant strains of bacteria have then emerged, forcing a return to aggressive surgical therapy. In addition, the incidence of empyema has increased as medical advances have enhanced survival of the elderly, the debilitated, cancer patients, and transplant patients—groups in which empyema is seen more often than in

the general population.

Empyema may be classified as acute or chronic. In the acute stage, obliteration of the pleural space is possible with adequate antibiotic therapy and closed drainage. In the chronic stage, effective obliteration is impossible without surgical measures, such as prolonged open drainage, decortication, or thoracoplasty. The pathologic changes that result in the development of chronic empyema are either loculation of the empyema space or development of a thick epipleural fibrous membrane that traps the underlying lung² (figure 1).

Historical background

Surgical management of empyema dates back to Hippocrates' treatise *De Morbis*, in which the following passage is found³:

The patient should be seated in a chair, his arms firmly pinned by assistants; grasping his shoulders, his body should be vigorously shaken while the surgeon's ear is applied to the chest, so that he may judge the

location of the fluid collection from the sound induced by the displacement thereof. If the medical man cannot gain sufficient knowledge in this way, he must then apply to the patient's chest a piece of cloth impregnated with Eutric earth [a substance having irritating properties like the modern mustard plaster] and moistened with warm water. Where the plaster first begins to dry out, there he may conclude the pus collection lies directly beneath. But if this sign, too, should fail, then must the sur-

continued



Figure 1. Chest film demonstrating empyema that developed after thoracentesis. Large fluid collection is visible in right pleural space adjacent to chest wall.

Empyemas may develop from pulmonary, mediastinal, or subdiaphragmatic causes or may result from direct inoculation.



David J. Cohen

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geon make his incision beside the rib which juts out farthest—quite low down and rather in front than behind. . . . The incision should be made with a large bistouri. . . . The edge of the instrument should be so guarded as to lay bare no more

tissue than the width of a man's thumb nail. After a certain portion of the pus has been permitted to run out, there should be introduced a tent or seton of raw flax with a thread attached.

The modern history of empyema treatment dates back to the Empyema Commission Report of World War I, edited by Graham and Bell.⁴ The commission found that a mortality of 30% to 70% was associated with drainage of empyema at various US Army camps. Further, the commission discovered that the military patients often had streptococcal empyema rather than the pneumococcal type common in civilian practice and that in the streptococcal type, adhesions did not form early. If the empyema was drained, the patient often died of pneumothorax and mediastinal instability. These discoveries led to the introduction of closed water-seal drainage, which reduced mortality to less than 15%.

Pathogenesis and epidemiology

Empyemas may develop from pulmonary, mediastinal, or subdiaphragmatic causes or may result from direct inoculation (figure 2). Primary pulmonary infection—usually pneu-

monia—is the most common cause. In a few cases, the empyema is secondary to bronchogenic carcinoma, septic infarction, or tuberculosis. Sometimes a lung abscess ruptures into the pleura, causing an empyema.

Mediastinal sources of empyema include tracheoesophageal fistula, an abscessed lymph node, and spinal osteomyelitis. Subdiaphragmatic sources include subphrenic abscess and liver abscess. Direct inoculation leading to empyema may result from infected hemothorax after trauma, spontaneous pneumothorax, thoracentesis, and postoperative leakage of the bronchial stump.²

Empyema tends to occur in debilitated patients. Common underlying factors include alcoholism, bronchitis, asthma, emphysema, diabetes, tuberculosis, carcinoma, heroin addiction, and steroid therapy. As would be expected, the prognosis for these patients is worse than for otherwise healthy patients with uncomplicated postpneumonic empyema.⁵

Microbiology

The bacteriology of empyema is constantly changing. In the preantibiotic era, the predominant organisms were *Streptococcus* and *Diplococcus pneu-*

Symptoms of empyema may be nonspecific and may include pleuritic pain and persistence of fever despite antibiotic therapy adequate to treat pneumonia.

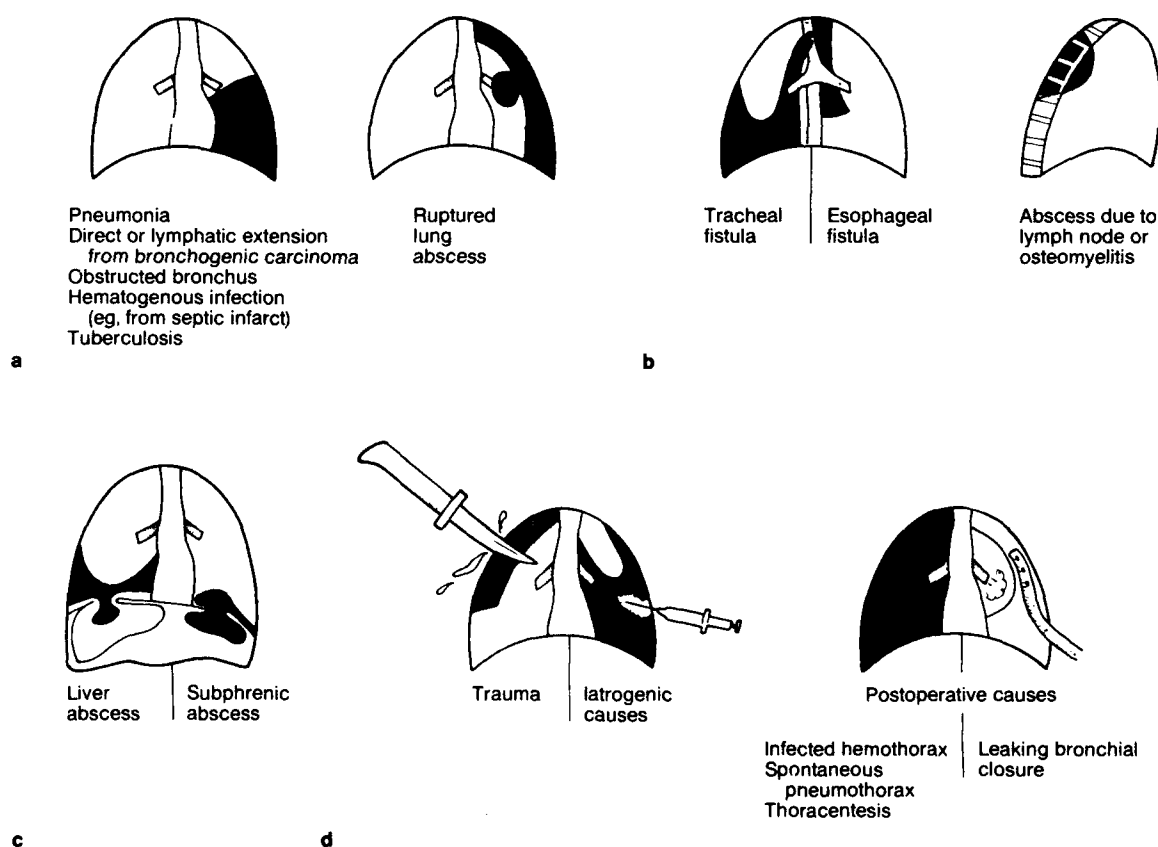


Figure 2. Causes of empyema. a. Pulmonary. b. Mediastinal. c. Subdiaphragmatic. d. Direct inoculation.

moniae. The latter is now known as *Strep pneumoniae*. Following widespread use of penicillin during and after World War II, pneumococcal empyema was rarely seen, leading some physicians to believe that

empyema had been virtually eliminated. Unfortunately, empyema due to *Staphylococcus aureus* and gram-negative organisms began to appear—especially in infants and children—prompting a resurgence of ag-

gressive surgical approaches as mortality rates climbed. After the introduction of methicillin in the early 1960s, treatment of empyema again became somewhat relaxed.

Today, no single organism

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For all undiagnosed pleural effusions, aspiration and Gram staining are mandatory.

predominates in empyema. In postthoracotomy empyema, which usually results from a bronchial stump leak or from contamination during surgery, the usual organism is *Staphylococcus* or a gram-negative bacillus. With parenchymal infection, such as aspiration pneumonia, anaerobes are found. *Strep pneumoniae* is the usual organism in classic postpneumococcal empyema. Other organisms are found in empyema from other causes.

Recently, the importance of anaerobic organisms has been recognized, especially in what had previously been thought to be "sterile empyema." Bartlett and associates⁶ found anaerobic bacteria alone in 34% of patients with empyema, anaerobes and aerobes combined in 42%, and aerobes alone in only 24% of patients. Thus, 76% of cases involved anaerobic organisms. The most common anaerobes isolated were various species of *Bacteroides*. Among the aerobes, *Staph aureus*, *Escherichia coli*, and *Pseudomonas* predominated.

Diagnosis

Diagnosis of empyema is occasionally difficult. Symptoms may be nonspecific and may include pleuritic pain and persistence of fever despite antibi-

otic therapy adequate to treat pneumonia. Physical findings might include impaired motion of the affected hemithorax, dull percussion note, reduced or absent breath sounds, and diminished vocal and tactile fremitus over the involved area. Chest films show pleural fluid. An upright posteroanterior view shows blunting of the costophrenic angle if 500 ml or more of fluid is present. Lateral decubitus views can be helpful for demonstrating smaller amounts of fluid and for differentiating fluid from pleural thickening. Anemia, dyspnea, lassitude, and clubbing of the fingers may occur in chronic stages.

An untreated empyema may drain spontaneously through the chest wall (empyema necessitatis), where it may be mistaken for a furuncle or subcutaneous abscess (figure 3), or into the lung, causing a bronchopleural fistula. Sudden rupture of a large empyema into a bronchus may flood the bronchial tree and has even been known to drown the patient.³ Detection of an air-fluid level on the chest film implies the presence of a bronchopleural fistula.

The diagnosis of empyema is established by Gram staining and culture of the fluid obtained by thoracentesis. Aspiration and Gram staining are

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Treatment of empyema differs depending on whether it is in the early, or exudative, stage, the fibrinopurulent stage, or the final, or organizing, stage.

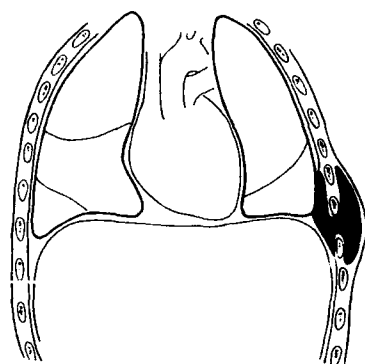
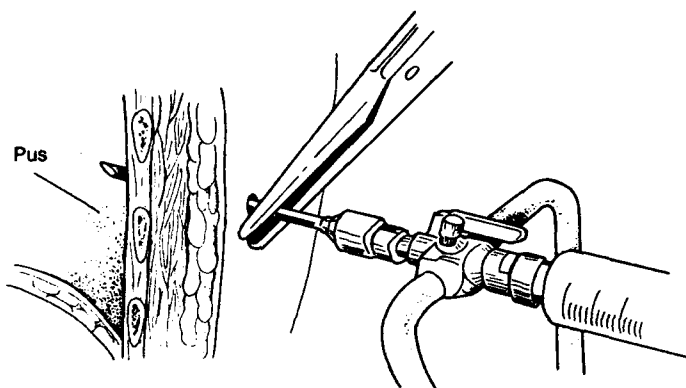
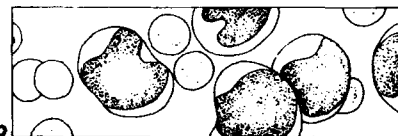


Figure 3. Untreated empyema draining spontaneously through chest wall (empyema necessitatis).

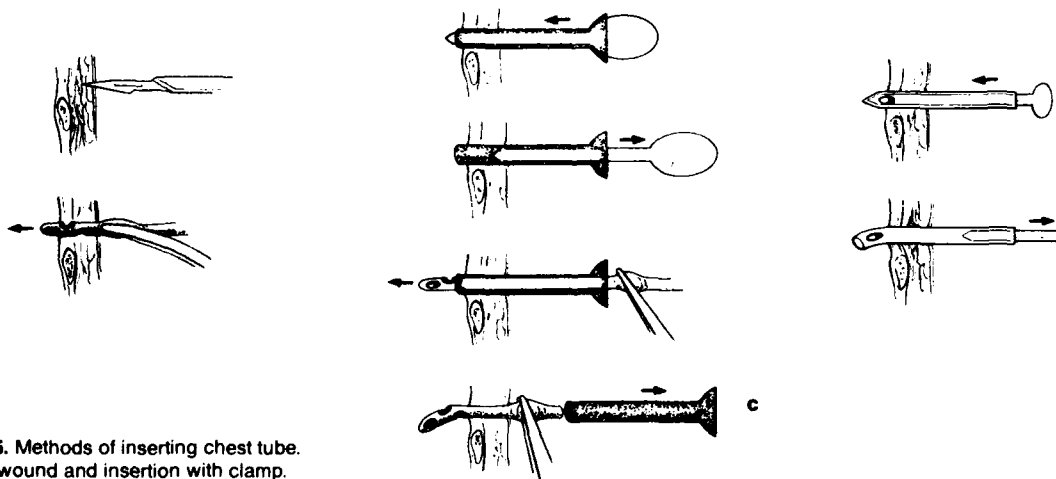


a



b

Figure 4. Aspiration of pleural effusion (a) and simulated Gram stain of aspirated fluid (b).



b

Figure 5. Methods of inserting chest tube.
a. Stab wound and insertion with clamp.
b. Insertion through trocar.
c. Trocar chest tube.

Regardless of the stage of empyema or type of drainage used, the drain must be in a dependent location in the empyema cavity.

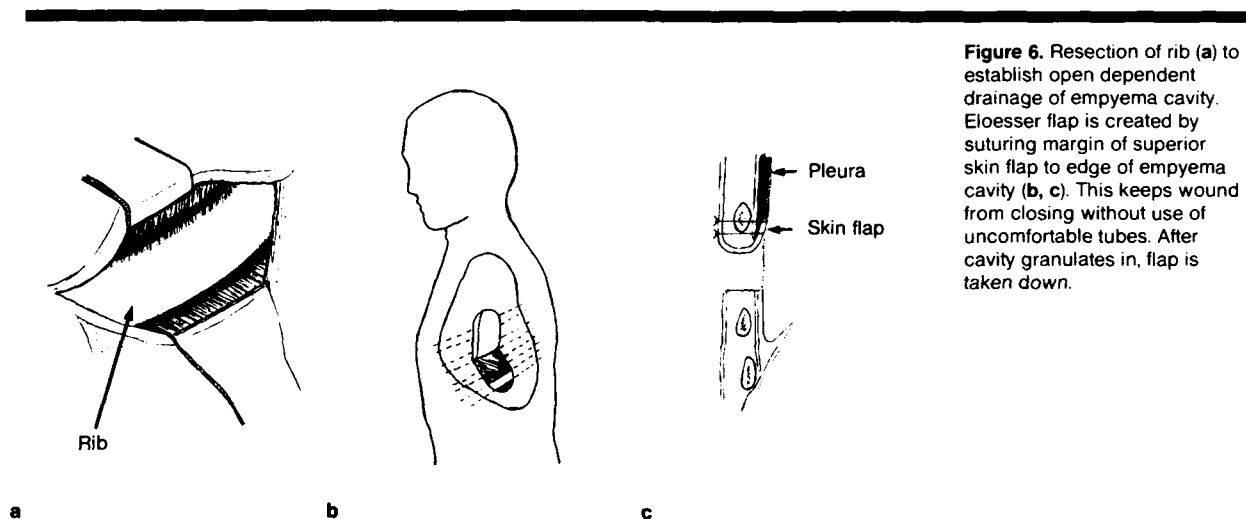


Figure 6. Resection of rib (a) to establish open dependent drainage of empyema cavity. Eloesser flap is created by suturing margin of superior skin flap to edge of empyema cavity (b, c). This keeps wound from closing without use of uncomfortable tubes. After cavity granulates in, flap is taken down.

mandatory for all undiagnosed pleural effusions. The character—especially the thickness—of the fluid should be noted, as this may be important in determining treatment (figure 4). Examination of the pleural fluid usually discloses polymorphonuclear leukocytes and bacteria. Protein level is usually greater than 3.0 gm/dl and specific gravity greater than 1.016.

Therapy

The treatment of empyema is based on administration of appropriate antibiotics plus provision of adequate dependent drainage and obliteration of dead space. Antibiotics are chosen on the basis of Gram staining of pleural fluid, and the selection is later modified by

culture results.

Surgical procedures used in draining and treating empyema include thoracentesis, closed chest tube drainage, open drainage plus rib resection, decortication, thoracoplasty, and excision of the empyema sac with an extrapleural dissection.

The type of treatment depends on the stage of the empyema.⁷ In the early, or exudative, stage, when there is an outpouring of thin fluid with a low cellular content, thoracentesis may be used to drain the pleural space, ie, tap it dry. If fluid buildup recurs, this procedure may be repeated once. However, if fluid builds up again—and in some cases at the first recurrence—a chest tube should be inserted and closed

water-seal drainage instituted (figure 5). Open drainage during this phase is contraindicated, since pneumothorax will result.

In the fibrinopurulent stage, when there is an accumulation of large quantities of frank pus with great numbers of polymorphonuclear leukocytes and fibrin, chest tube drainage may still be effective. Fibrinolytic enzymes have been used during this phase to promote drainage, but with little success. Drainage tubes must be left in place until the cavity is completely obliterated by expansion of the lungs, as demonstrated on a sinogram.

In the final, or organizing, stage of empyema, fibroblasts grow into the exudate on both the visceral and parietal sur-

Since the introduction of methicillin, pleural empyema in children has become less virulent.

faces, producing an inelastic membrane, or "peel." Once this phase occurs, open drainage with rib resection may be necessary to remove thick pus and coagulated exudate or to free loculations^{8,9} (figure 6).

Regardless of the stage of empyema or the type of drainage used, it is essential that the drain be in a dependent location in the empyema cavity.

Early decortication became popular during World War II.¹⁰ It was especially useful for traumatic hemothoracic empyema when more than 25% of lung compression was noted or when clinical deterioration became apparent. In these cases the morbidity and mortality resulting from contaminated hemothorax were significantly decreased by early decortication, which allowed immediate reexpansion of the lung and obliteration of the empyema cavity.

Empyema due to pneumonia was treated differently from that due to trauma. Burford and associates¹⁰ suggested decortication within two to three weeks in cases of bacterial empyema, because beyond that time tufts of scar tissue extend through the pleura into the lung, making decortication more difficult. Other authors¹¹ have suggested early decortication if a febrile and toxic course

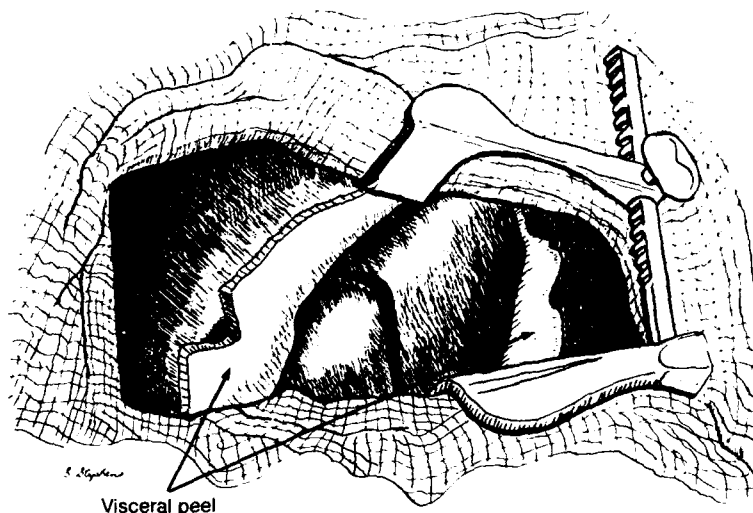


Figure 7. Decortication. Visceral peel (arrows) is removed from lung.

persists for seven to ten days despite drainage and administration of antibiotics, if a woody layer is felt on thoracentesis, or if multiple air-fluid levels are present. Others feel that failure of tube drainage to yield significant improvement in 48 to 96 hours is an indication for decortication. Generally, patients improve fairly rapidly after decortication, and chest tubes can be removed after a few days.¹²

Although decortication usually means removing the visceral peel, sometimes both visceral and parietal peel are removed,

as well as the membranes on the diaphragm and mediastinum. Removal of the peel is much easier if done early (figure 7).

Other means of therapy include thoracoplasty and excision of the empyema sac with an extrapleural dissection. Thoracoplasty should rarely be needed, and then only if all other methods fail to allow reexpansion of the lung and obliteration of the cavity. Thoracoplasty implies subperiosteal rib resections, which allow the chest wall to collapse onto the mediastinum, obliterating dead space (figure 8).

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Management of postpneumonectomy empyema is made more difficult by the lack of lung to fill the empyema space.

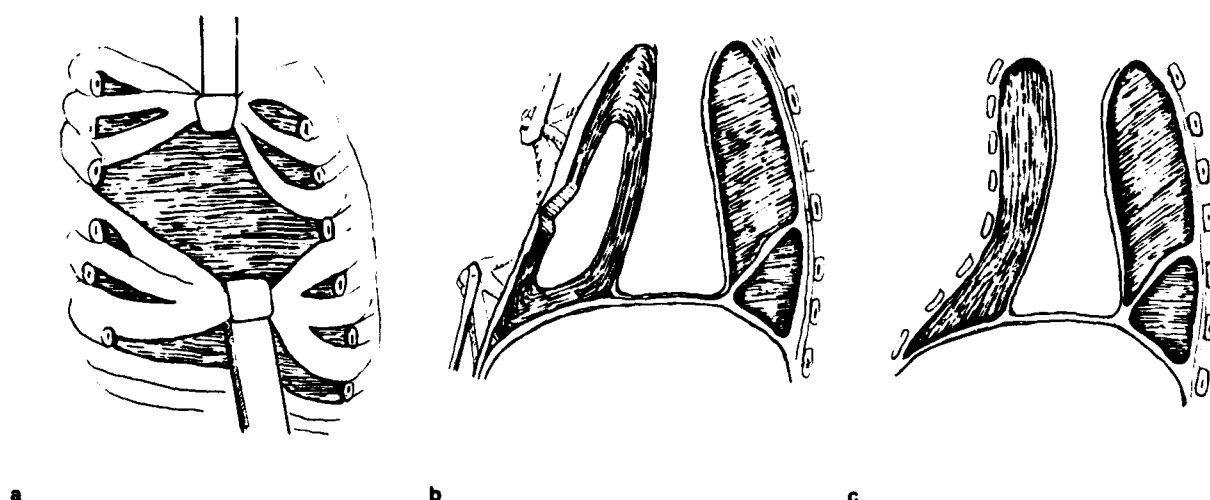


Figure 8. Fundamentals of thoracoplasty. Ribs are resected (a), allowing muscles of chest wall to fall against mediastinum (b), thus obliterating pleural cavity (c).

Special types of empyema

Empyema in children and postpneumonectomy empyema require special consideration.

EMPYEMA IN CHILDREN—In the late 1950s, empyema due to *Staph aureus* became very common and had a high mortality. Staphylococcal empyema was often associated with the formation of pneumatoceles and pneumothorax. In that era, pediatric practice dictated insertion of a chest tube when pleural fluid contained gram-positive cocci. This often was converted to open drainage with rib resection and finally to decortication.

Since the introduction of methicillin in 1963, pleural empyema in children has become less virulent. In 1970, Stiles and co-workers¹³ reviewed their series of pediatric empyema cases in Los Angeles and showed that most had been handled successfully by antibiotics plus thoracentesis alone. A chest tube was required in a few cases, but almost none of their patients required open drainage or decortication. Thick pleural peel and pneumatoceles gradually resolved without pulmonary function defects. On the basis of their study, Stiles and associates¹³ suggested basing ther-

apy on the clinical febrile course rather than on the radiographic findings.

POSTPNEUMONECTOMY

EMPHYEMA—This type is usually caused by a breakdown of the bronchial stump. Management is made more difficult by the lack of lung to fill the empyema space. In the past, drainage plus rib resection was performed first. Subsequently, the bronchopleural fistula was closed with a muscle flap and a large mutilating thoracoplasty was performed.

In 1963, Clagett and Geraci¹⁴ introduced an alternative approach. Open drainage of the infected chest was obtained using an Eloesser flap. After the bronchopleural fistula was closed, the cavity was irrigated with half-strength Dakin's solution. When purulent drainage subsided in four to eight weeks, the Eloesser flap was taken down, the cavity filled with a solution containing neomycin, and the chest primarily closed. Stafford and Clagett,¹⁵ in 1972, reported that empyemas were successfully closed this way at the first attempt in 11 of 18 patients. When the technique was repeated, closure was successful in three of the remaining patients. Others have enjoyed similar success using this technique.¹⁶

Summary

The incidence and treatment of empyema historically have fluctuated with the introduction of new antibiotics. As resistant strains of bacteria emerge, a return to aggressive surgical therapy becomes necessary.

Empyemas are most likely to occur in patients with an underlying factor such as alcoholism, bronchitis, asthma, emphysema, diabetes, tuberculosis, carcinoma, heroin addiction, or steroid therapy. The bacteriology is constantly changing. Recently, the importance of anaerobic organisms—which are now involved in three out of four cases of

empyema—has been recognized.

Diagnosis is established and antibiotics chosen on the basis of Gram staining and culture of pleural fluid. Surgical procedures include thoracentesis, closed chest tube drainage, open drainage plus rib resection, decortication, thoracoplasty, and excision of the empyema sac with an extrapleural dissection. FGM

The views expressed herein are those of the author and do not necessarily reflect the views of the United States Army or the Department of Defense.

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